Assignment 12: Robot Localization
CS 730/830, Spring 2025
Due at **11pm on Mon Apr 28**

Overview

You will write a program that, given a map of the environment and a series of actions and noisy sensor measurements, produces estimates of a robot's location over time. We recommend using Monte Carlo localization (a particle filter).

The map will be given on standard input in the same textual format as in previous assignments (such as 1, 2, and 3). All cells will be either empty (`_`) or blocked (`#`). The robot's state is simply integer $\langle x, y \rangle$ coordinates.

Given an action (north, south, east, west), the robot correctly executes the action with probability 0.7. The robot goes 90 degrees off the intended direction with probability 0.1 for each alternative. And with probability 0.1, the robot stays where it is. If the result of those dynamics would cause the robot to enter an obstructed cell, it stays where it is instead.

The sensor returns the location of the robot, corrupted by Gaussian noise with mean zero and a known variance σ^2 (the same in both coordinates). Note that the probability of a location $\langle x, y \rangle$ given a two-dimensional Gaussian with variance σ^2 located at $\langle \mu_x, \mu_y \rangle$ is proportional to $\exp(-(\frac{(x-\mu_x)^2}{2\sigma^2} + \frac{(y-\mu_y)^2}{2\sigma^2}))$.

We recommend including some particle rejuvenation, such as generating 10% of your particles uniformly at random.

Input/Output

Your program should take two optional command-line arguments:

`--sigma` σ the standard deviation of the sensor noise. Default could be 2.

`--particles` n the number of particles you should use. Default could be 100.

At each time step, the robot executes an action and receives sensor data and then your program needs to produce an updated location estimate. You will receive the new sensor measurement (noisy $\langle x, y \rangle$) and the action that was executed, as in:

```
1.458804 3.936243 EAST
```

You should perform an update to your estimate, given this new data. Then, print your current estimate to standard output as a set of weighted particles $\langle x, y, weight \rangle$, one per line:

```
1 3 0.2
1 2 0.001
1 1 0.001
```

If you receive the message `END` instead of a sensor measurement, your program should terminate.

Supplied Utilities

We supply:

`mcl-reference` a sample solution.

`mcl-tester` a test harness to evaluate your program and visualize its behavior. It takes the name of your program, then the same arguments as your program (which it will pass along to you).

`problems.zip` some sample input maps

Submission

Along with your code, submit a brief write-up answering the following questions:

1. Describe any implementation choices you made that you felt were important. If you implement anything beyond the assignment as written, please be sure to discuss it. Clearly explain any aspects of your program that aren't working. Mention anything else that we should know when evaluating your work.

2. What suggestions do you have for improving this assignment in the future?